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Trends in 30-Day Readmission Rates for Patients Hospitalized With Heart Failure: Findings From the GWTG-HF Registry

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Abstract

Background—Reducing hospital readmissions for patients with heart failure is a national priority, and quality improvement campaigns are targeting reductions of 20% or greater. However, there are limited data regarding whether such targets have been met.

Methods and Results—We analyzed data from the American Heart Association's Get With The Guidelines-Heart Failure (GWTG-HF) registry linked to Medicare claims between 2009 and 2012 to describe trends and relative reduction of rates of 30-day all-cause readmission among

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patients with heart failure. A total of 21,264 patients with heart failure were included from 70 US sites from January 2009 to October 2012. Overall hospital-level risk-adjusted 30-day all-cause readmission rates declined slightly, from 20.0% (SD, 1.3%) in 2009 to 19.0% (SD, 1.2%) in 2012 (P = .001). Only 1 of 70 (1.4%) hospitals achieved the 20% relative reduction in risk-adjusted 30-day readmission rates. A multivariable linear regression model was used to determine hospital-level factors associated with relative improvements in 30-day risk-adjusted readmissions between 2009 and 2012. Teaching hospitals had higher relative readmission rates as compared to their peers, and hospitals that used postdischarge heart failure disease management programs had lower relative readmission rates.

Conclusions—While there has been slight improvement in 30-day all-cause readmission rates over the past 4 years in patients with heart failure, few hospitals have seen large success.

Keywords

heart failure; outcome and process assessment (health care); readmission

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Heart failure is a substantial burden on the US health care system, affecting 5.7 million Americans at an annual cost of $30.7 billion.[1] Of these costs, 68% are attributed to direct medical expenditures,[1] a large portion due to hospitalizations for decompensated heart failure.[2] Though overall hospitalization rates for heart failure decreased for Medicare beneficiaries between 1998 and 2008,[1,3] unplanned readmissions continue to be a common occurrence, with nearly 1 in 4 patients being readmitted within 30 days of discharge.[4]

The rising cost of health care has garnered significant national attention, leading to public reporting by the Centers for Medicare & Medicaid Services (CMS) of risk-adjusted unplanned all-cause readmission rates among patients with heart failure in 2009.[4] Reimbursement policies were implemented to incentivize hospitals to reduce readmissions by decreasing hospital Medicare reimbursement for hospitals with higher than predicted readmission rates.[5] These actions led to several national campaigns aimed at helping hospitals decrease rates of unplanned readmissions.[2]

These programs were designed to help providers and health care institutions share strategies for optimizing transitions of care from inpatient to outpatient settings, with ambitious goals set in October 2009 of reducing 30-day readmissions for patients with heart failure by 20% nationwide by December 2012.[6] Several studies have evaluated the use and efficacy of strategies employed by individual hospitals participating in these programs,[5,7–9] but no work to date has identified the characteristics of hospitals that have successfully reduced unplanned 30-day readmissions. Similarly, data on temporal trends of national rates of readmission have been published,[4] but no studies with clinical and administrative data have examined relative reductions in readmission rates achieved by hospitals over the past few years.

Here, we describe trends in 30-day all-cause readmission rates from 2009 to 2012 among patients with heart failure and explore care processes and hospital factors associated with the trends. We examined a subset of hospitals voluntarily participating in the Get With the Guidelines-Heart Failure (GWTG-HF) national quality improvement program.

Methods

Data Sources

We combined data from the GWTG-HF registry, the American Hospital Association Survey on Hospital Characteristics, the Dartmouth Atlas of Healthcare, CMS administrative claims, and the CMS Hospital Compare data. The institutional review board of the Duke University Health System approved the study.

The GWTG-HF program, a voluntary hospital-based initiative launched in 2005 to improve care of patients with heart failure by translating guidelines into clinical practice,[10,11] was used to evaluate clinical characteristics of patients included in the study. Hospitals participating in GWTG-HF report on a number of quality and performance measures for eligible patients. Patients are considered eligible when hospitalized with a primary discharge diagnosis of heart failure. Clinical data are submitted in compliance with Joint Commission and CMS standards. Participating hospitals submit clinical information regarding the medical history, hospital care, and outcomes of patients hospitalized for heart failure using an online, interactive case report form and patient management tool. Quintiles serves as the data collection coordination center for the GWTG-HF program.

Hospital-specific data were taken from the American Hospital Association Database[12] by linking the responding GWTG-HF hospital with the American Hospital Association ID number.[13] The American Hospital Association Survey Data is compiled from an annual national survey of over 6500 hospitals and includes information pertaining to hospital characteristics and services available. Data quality is monitored and assured via electronic data checks. Regional hospital data were obtained from the Dartmouth Atlas of Health Care, specifically measures of physician capacity, community health, and guideline adherence.

We linked Medicare inpatient claims from January 1, 2009, through December 31, 2012, with data from GWTG-HF, using a method described previously.[13] Medicare inpatient claims consist of institutional claims submitted for facility costs covered under Medicare Part A (ie, hospitalizations).

The Hospital Compare database (https://www.medicare.gov/hospitalcompare/) reports on risk-standardized outcomes of acute care hospitals for specific patient populations using methods developed for CMS.[14]

Study Population

A hospital is designated as fully participating in GWTG-HF if it provides at least 75% of the medical history panel for included patients. Patients were included if they were discharged on or before November 1 of each calendar year to allow for 30 days of follow up for each patient in the study. Patients were excluded from the analysis if they were ineligible for fee-for-service Medicare at the time of discharge from the index hospitalization, they died in hospital, their discharge status was missing or not documented, they left against medical advice, or they were transferred to an acute care facility. Hospitals were excluded if they had fewer than 10 patients in GWTG-HF in 2009 or 2012.

Sites analyzed for the sensitivity analysis from the Hospital Compare database were excluded only if they were missing risk-adjusted 30-day readmission rates.

Patient and Hospital Characteristics

From the GWTG-HF registry, we obtained patient demographic characteristics, medical history, results of admission laboratory tests and evaluations, and laboratory tests at discharge. We also obtained hospital characteristics based on eligible and nonmissing patients from the registry, including the percentage of patients referred to an outpatient disease management program, the percentage of discharge instructions completed, the percentage of patients with left ventricular systolic dysfunction (LVSD) who were prescribed a β-blocker, the percentage of patients with LVSD who were prescribed an angiotensin-converting enzyme (ACE) inhibitor or angiotensin II receptor blocker (ARB), and the median length of hospital stay.

Additional hospital characteristics were obtained from the American Hospital Association Database, including hospital type, presence of a cardiac intensive care unit, availability of adult diagnostic or interventional catheterization and heart transplant services, total number of beds, annual number of Medicare and Medicaid discharges, urban/rural setting, and US geographic region. Finally, we obtained regional hospital characteristics from the Dartmouth Atlas, including proxies for physician capacity (ie, number of cardiologists per 100,000 residents), community health measures (ie, rate of leg amputation, discharge for ambulatory care–sensitive conditions per 1000 Medicare beneficiaries),[15] and guideline adherence for cardiovascular disease (ie, percentage of patients filling a β-blocker prescription between 1 and 6 months and 7 and 12 months after myocardial infarction, percentage of patients with diabetes mellitus who filled an ACE inhibitor or ARB prescription).[16] Dartmouth Atlas characteristics are widely used to provide a detailed look at variation in medical care inputs, use, and outcomes.[17,18] Because the atlas currently has no measures directly pertaining to heart failure clinical care, we chose to use measures related to general cardiovascular disease and cardiovascular prevention practices as a proxy to describe regional variation in inpatient and outpatient care.[16]

Outcomes

The study population was evaluated for the number of annual unplanned heart failure readmissions occurring within 30 days, with day 0 defined as the discharge date for the index heart failure hospitalization. Unplanned readmissions were defined as unintentional readmissions, not a scheduled part of a patient’s plan of care, within 30 days and 60 days of discharge from an acute care hospital, as described previously.[19] Admissions to rehabilitation facilities (*International Classification of Diseases, Ninth Revision, Clinical Modification* [*ICD-9-CM*] diagnosis code V57.xx or DRG code 945 or 946) were excluded. We performed a secondary analysis with an outcome of 30-day heart failure–specific readmission using definitions similar to above (Supplemental Table 1).

Statistical Analysis

For baseline patient and hospital characteristics, we present categorical variables as frequencies and percentages and continuous variables as means with SDs, medians and interquartile ranges. We compared categorical variables using Fisher exact test. We compared continuous variables using Kruskal-Wallis tests. We examined patient and hospital characteristics for the following groups: (1) overall population, (2) whether sites reached 20% relative reduction in risk-adjusted 30-day readmission rates between 2009 and 2012, (3) quartiles of relative change between 2009 and 2012 in 30-day risk adjusted readmission rates, (4) whether sites reached 20% relative reduction in risk adjusted 60-day readmission rates between 2009 and 2012, (5) quartiles of relative change between 2009 and 2012 in 60-day risk adjusted readmission rates. Groups 2 through 5 were based on a site-level comparison. We evaluated the relationship between baseline readmission rates and relative rate reduction by calculating relative change in 30-day risk-adjusted readmission rates between 2009 and 2012 as a function of quartiles of 2009 risk-adjusted readmission rates using a Kruskal-Wallis test. We also calculated baseline characteristics of hospitals making referrals to heart failure disease management programs above and below the median rate (Supplemental Table 2).

We calculated unadjusted, unplanned 30-day and 60-day readmission rates per site for each year. We determined trends across admission years using an unadjusted linear regression model with GEE to account for in-hospital clustering, with percent readmission as the outcome and admission year as the explanatory variable. We calculated risk-adjusted readmission rates per hospital using patient-level covariates, as previously described,[20] including demographic characteristics (ie, age, sex, race, insurance), medical history (ie, anemia, atrial fibrillation, chronic obstructive pulmonary disease or asthma, cerebrovascular accident or transient ischemic attack, depression, diabetes mellitus, dialysis, hyperlipidemia, hypertension, peripheral vascular disease, renal insufficiency, smoking, ischemic history), vital signs and laboratory tests at admission (ie, systolic blood pressure, weight, heart rate, respiratory rate, serum sodium, serum creatinine, blood urea nitrogen [BUN], B-type natriuretic peptide [BNP], troponin, hemoglobin, ejection fraction), and laboratory tests at discharge (ie, serum sodium, serum creatinine, serum potassium, weight difference). We ran 4 adjusted hierarchical logistic models with hospital-specific random intercepts for each year of interest for 30-day readmission. We calculated the risk-adjusted readmission rate per site using the CMS algorithm, as previously described.[4] Risk-adjusted readmission rates were also calculated for 60-day readmissions. If a patient had unknown medical history status, it was imputed to no, because we assumed the field was not filled out when not applicable. We used single multivariable imputation by fully conditional specification to impute missing data for all other patient-level covariates to account for possible confounders. We used hospital-specific risk-adjusted 30-day readmission rates to determine relative changes in readmission per hospital to describe hospital variation over time. We used these data to calculate the 30-day and 60-day risk-adjusted readmission rates in 2009 and 2012, the relative change in 30-day and 60-day general risk-adjusted readmission rates between 2009 and 2012, and the proportion of sites that were able to achieve a relative reduction of 20% in risk-adjusted 30-day and 60-day readmission rates. We also calculated mortality rates in 2009 and 2012 using simple linear regression to assess the competing risk of death.

We sought to examine associations between relative change in readmission rates between 2009 and 2012 for hospitals and the hospital factors of interest previously listed. We assigned missing hospital characteristics using multiple imputation with fully conditional specification methods, generating 25 imputed data sets. We performed forward selection on 19 factors based on a *P* value with a cutoff of .20 for each imputation data set separately to identify final factors associated with relative change in 30-day risk-adjusted readmission. Factors that entered the model for at least 20 out of the 25 imputed data sets (80% of the time) were included in the final multivariable linear regression model. We assessed the normality of continuous outcomes and applied transformations, if appropriate. We also applied the same final factors after forward selection to relative change in 60-day risk-adjusted readmissions. The same methodology was used to examine associations between 30-day and 60-day risk-adjusted readmission rates of hospital sites in 2012 and hospital factors of interest to determine the impact of factors on general rates of risk-adjusted readmission rates (Supplemental Table 3). The final models included no imputed variables.

Finally, we performed a sensitivity analysis designed to ensure that our study population had similar rates of relative change in readmissions to hospitals nationwide. Since the collection period for the Hospital Compare risk-adjusted readmission rate is 36 months, we compared the 30-day readmission rates for July 2006–June 2009 and July 2009–June 2012. We used these data to calculate the proportion of hospitals in the Hospital Compare database that reduced their relative 30-day risk-adjusted readmission rates by 20%, as well as the mean and median 30-day risk-adjusted readmission rates for July 2006–June 2009 and July 2009–June 2012. We used SAS version 9.3 (SAS Institute Inc, Cary, North Carolina) for all data generation and analyses.

Results

There were 49,829 patients from 240 fully participating hospital sites present in the linked GWTG-HF and Medicare patient populations from January 1, 2009, to December 31, 2012. A total of 1825 (3.7%) patients and 1 (0.4%) hospital site were excluded due to being ineligible for fee-for-service Medicare at the time of index hospitalization discharge. Other exclusions were as follows: 1684 (3.4%) patients died in hospital; 1212 (2.4%) patients had undocumented or missing discharge status, left against medical advice, or were transferred to an acute care facility; and 7839 (15.7%) patients and 4 (1.7%) hospitals had index hospitalizations after November 1 of each calendar year. There were 165 (68.8%) hospitals with fewer than 10 patients in 2009 or 2012, leading to exclusion of those sites and 16,005 (32.1%) patients.

The final study population included 21,264 patients from 70 hospitals admitted from January 1, 2009, to October 30, 2012. Unadjusted 30-day readmission rates ranged from 0.0% to 45.5% in 2009 and 5.6% to 38.5% in 2012, with no significant improvement in average site rate from 2009 to 2012 (Figure 1). For the aggregated hospital sites, risk-adjusted 30-day readmissions declined slightly, from 20.0% (SD, 1.3%) in 2009 to 19.0% (SD, 1.2%) in 2012 ($P = .001$). The median change in relative readmission rates for the 70 hospitals was −5.6% (interquartile range, −8.74% to −0.86%), with a range of −21.0% to 15.5% (Figure 2). Only 1 of the 70 (1.4%) hospitals achieved the goal of 20% relative reduction in 30-day risk-adjusted readmission rates (Figure 3). We found no statistically significant change in 30-day mortality rates between 2009 (7.8%) and 2012 (7.6%; $P = .71$). Baseline risk-adjusted 30-day readmission rates were found to predict greater decreases in relative risk-adjusted readmission rates between 2009 and 2012 ($P = .003$) (Table 1). We found no statistically significant differences across the characteristics evaluated (Table 2). When the 60-day time frame was evaluated, no hospital was able to achieve a 20% reduction in relative 60-day readmission rates between 2009 and 2012 (data not shown).

We identified 2 factors that were associated with the relative change in 30-day risk adjusted readmission rates. Hospitals that referred patients to heart failure disease management programs had lower relative readmission rates ($P = .03$). Teaching hospitals had higher relative risk-adjusted readmission rates than nonteaching hospitals ($P = .05$). The percentage of patients with LVSD who filled a prescription for an ACE inhibitor or ARB was not significantly associated with relative changes in risk-adjusted 30-day readmission rates (Table 3). We found that hospital sites that made referrals to heart failure disease management programs were more likely to be teaching hospitals and to have interventional catheterization labs, heart transplant services, greater number of beds and Medicare/ Medicaid discharges, and greater cardiologist capacity compared with peers. Patients from these sites had lower ejection fractions and hemoglobin and higher creatinine at admission. Patients were more likely to have renal insufficiency and hyperlipidemia. They were also younger and were of races other than white. Finally, patients at centers with a higher percentage of referrals had more Medicaid beneficiaries and fewer Medicare beneficiaries (Supplemental Table 2).

In the Hospital Compare sensitivity analysis data set, the total number of hospitals present was 4915. There were 1213 (24.6%) sites excluded due to missing previously calculated risk-adjusted readmission rates. The mean 30-day risk-adjusted hospital readmission rate was 24.7% (SD, 2.0%) in July 2006–June 2009 and was 23.1% (SD, 1.8%) in July 2009–June 2012 ($P < .001$). Of 3702 hospitals, 97 (2.6%) achieved a 20% relative decrease in risk-adjusted 30-day readmission rates from July 2006–June 2009 compared to July 2009–June 2012.

Discussion

Reducing hospital readmissions has become a national priority over the past 6 years. Only 1.4% of hospitals examined in this study achieved a 20% reduction in relative 30-day readmission rates by December 2012, a goal established in a prominent national quality improvement campaign.[4] This was comparable to hospitals examined from the Hospital Compare database, in which only 2.6% of hospital sites achieved a 20% relative reduction from July 2006–June 2009 vs July 2009–June 2012. These results for patients with heart failure are consistent with recent data that suggest improvements in general readmission rates for fee-for-service Medicare beneficiaries have been minimal, despite increased efforts of health systems and commitment of substantial resources focused on reducing readmissions.[4,7,8,21]

Linking CMS data with the GWTG-HF registry allowed evaluation of trends in readmission rates in the context of clinical and hospital factors, which shed light on the impact of structural hospital characteristics on readmission rates among patients with heart failure. Although we found that increasing referrals to heart failure management programs were associated with decreases in relative readmission rates, these improvements were modest and of borderline significance. However, our secondary analysis revealed that patients referred to the hospitals using these programs are different, and perhaps sicker, than hospitals that do not use the programs. This is a possible confounding variable. Certain structural hospital characteristics had a stronger association with reductions in relative readmission rates than the quality improvement measures we examined, with teaching hospital status having a larger expected association with relative risk-adjusted 30-day readmission rates compared to percentage of patients referred to heart failure management programs. Though the CIs were wide, teaching hospitals were found to have substantially higher relative readmission rates compared to nonteaching hospitals, paralleling findings from other studies of hospital 30-day readmission rates in heart failure.[5] Other quality improvement measures examined were not significantly associated with relative readmission rates; however, with only 70 hospitals included the ability of this study to detect significant associations for individual care measures may be limited.

One of the assumptions implicit in current efforts to reduce readmissions among patients with heart failure is that implementing general transition of care strategies along with specific strategies for patients with heart failure can result in significant reductions in readmission rates at a hospital level. While there are a number of studies indicating that that rigorous implementation of quality improvement initiatives results in improvements in readmission rates in select patients or single centers,[5,7–9] ours is among the first studies to suggest that structural aspects of hospitals may have a larger impact on readmission rates than previously considered. This finding implies that the control health systems have in achieving substantial improvements in readmission rates among patients with heart failure is limited. More work is needed to characterize the relative expected impact of inherent hospital characteristics vs quality improvement strategy implementation, particularly when considering how costly implementation of strategies can be in a resource-limited environment.

Our study has limitations. There may be measured and unmeasured residual confounding factors given the observational nature of our analysis. We focused on hospitals continuously participating in GWTG-HF during the study period and the results may not generalize to all hospitals nationwide. The number of hospitals included in the primary analyses was limited, but the changes in 30-day readmission rates and the proportion of hospitals with 20% relative reductions in readmission rates were similar to those observed in Hospital Compare. We were also limited in our ability to pinpoint reasons structural hospital factors were associated with changes in relative and general risk-adjusted readmission rates based on the factors we examined. Similarly, our patient population only consisted of patients enrolled in Medicare, thus we were unable to detect readmission trends present in hospitals for patients outside of government-provided insurance plans.

Conclusions

We found that small gains have been made in reducing relative all-cause readmission rates for patients with heart failure between 2009 and 2012, and few hospitals achieved a 20% reduction in their relative rate of readmission within this time period. Several hospital factors were associated with relative rates of readmission, with structural factors, particularly teaching hospital status, likely contributing the most to readmission rates as opposed to modifiable care delivery factors. Further work is required to identify modifiable components related to these structural factors to aid in continuing efforts to develop strategies that allow hospitals to achieve realistic reductions in readmission rates.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Clinical Perspective

Reducing hospital readmissions for patients with heart failure is a national priority, and quality improvement campaigns are targeting reductions of 20% or greater. We analyzed data from the American Heart Association's Get With The Guidelines-Heart Failure (GWTG-HF) registry linked to Medicare claims between 2009 and 2012 to describe trends and relative reduction of rates of 30-day all-cause readmission among patients with heart failure. In 70 US sites from January 2009 to October 2012 we found overall hospital-level risk-adjusted 30-day all-cause readmission rates declined slightly, from 20.0% (SD, 1.3%) in 2009 to 19.0% (SD, 1.2%) in 2012 ($P = .001$). Only 1 of 70 (1.4%) hospitals achieved the 20% relative reduction in risk-adjusted 30-day readmission rates. Teaching hospitals had higher relative readmission rates as compared to their peers, and hospitals that used postdischarge heart failure disease management programs had lower relative readmission rates. While there has been slight improvement in 30-day all-cause readmission rates in patients with heart failure, few hospitals have seen large success. Much more is needed to understand how to improve hospital readmission for patients with heart failure regarding how to identify and implement best practices nationally.

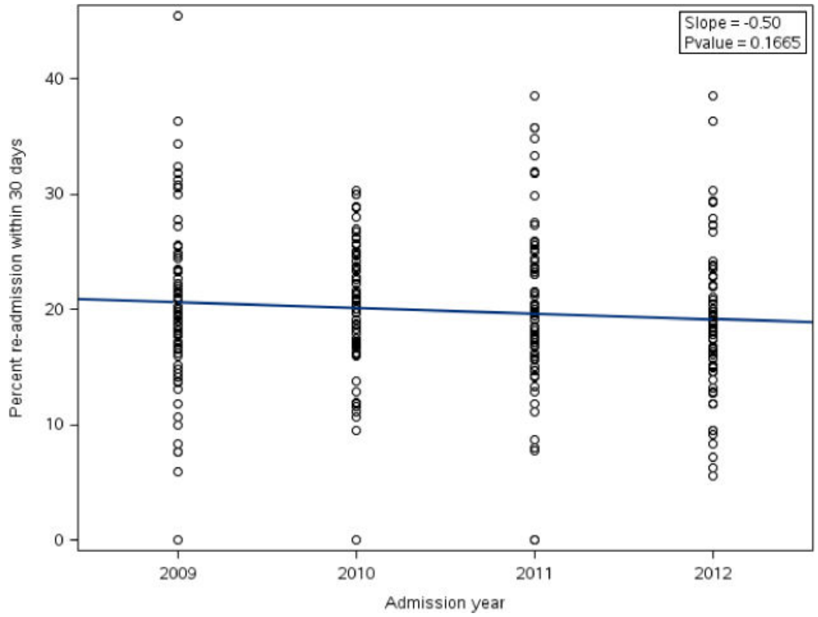

Figure 1. Unadjusted Unplanned 30-Day Readmissions by Year per Site

Displayed are unadjusted unplanned 30-day readmission rates per site for each year of interest. The figure shows a mean trend line across 4 years, which has a slope of −0.5; however, admission year is not statistically significant (*P* = .17).

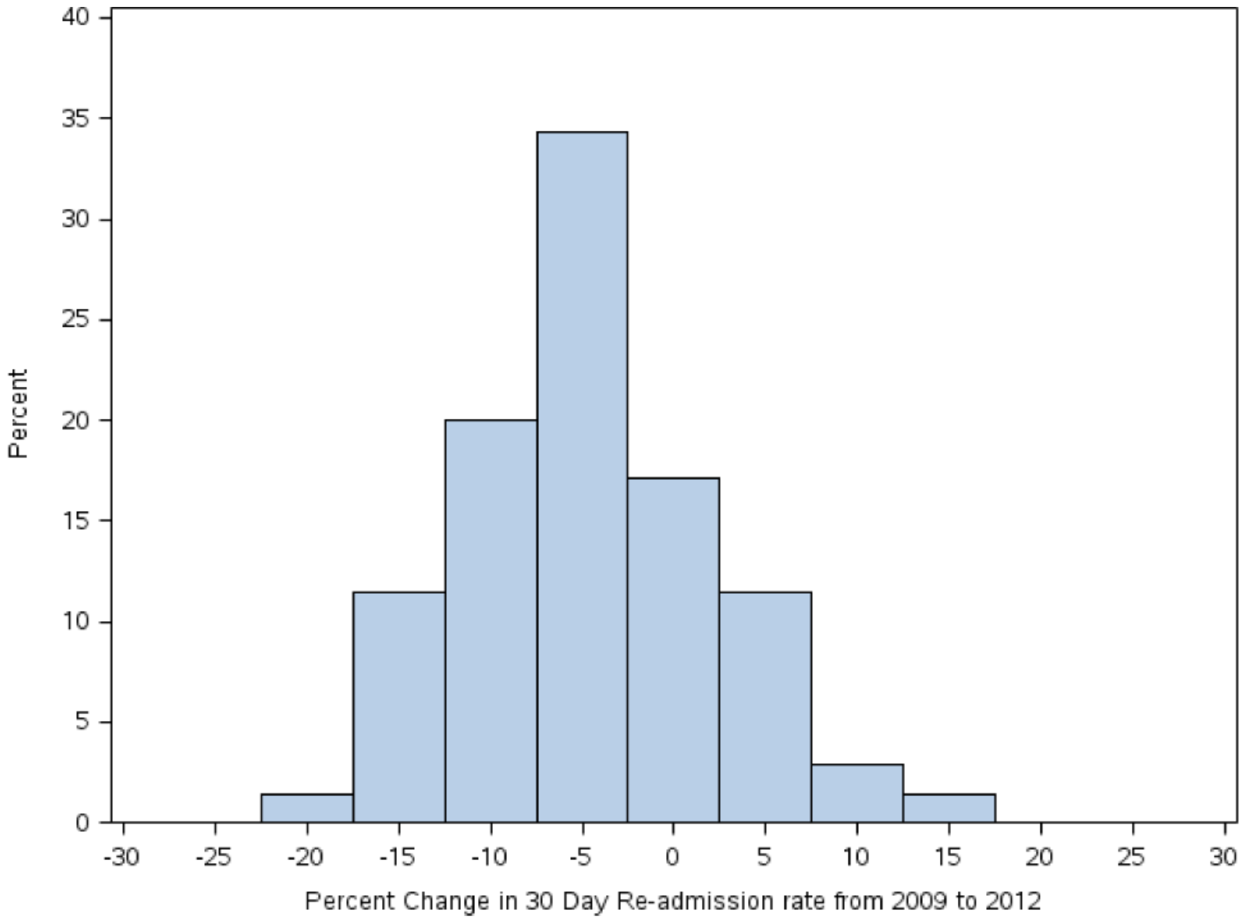

Figure 2. Proportion of Hospitals Achieving Varying Levels of Relative Change in 30-Day Risk-Adjusted All-Cause Readmission Rates

Displayed are the proportions of hospitals achieving relative percent changes in 30-day risk-adjusted readmission rates between 2009 and 2012.

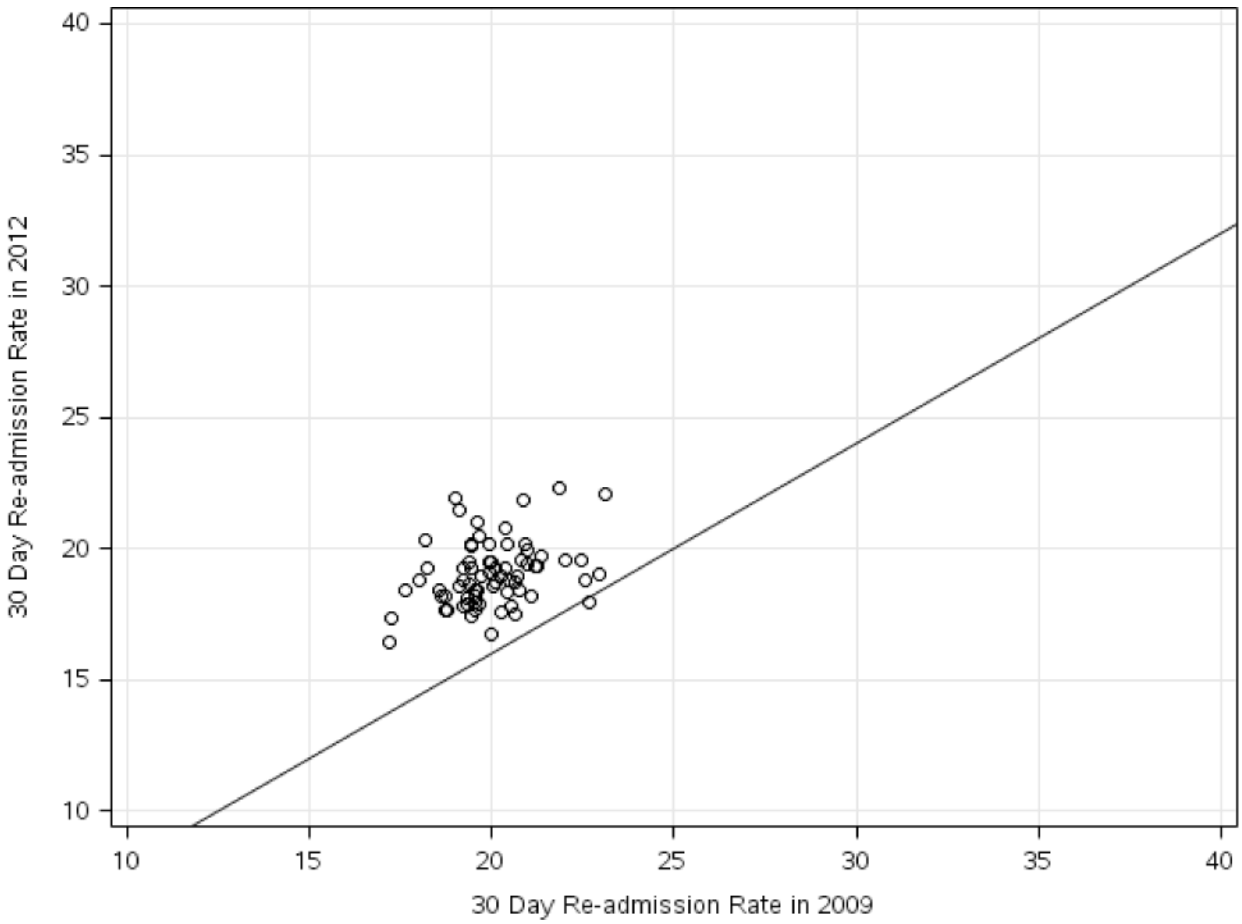

Figure 3. Comparison of 30-Day Risk-Adjusted All-Cause Readmission Rates in 2009 by 2012 per Hospital Site

Displayed are 30-day risk-adjusted readmission rates in 2009 compared with 2012 with a 20% relative change reference line. Hospitals above the line did not achieve the stated goal of 20% relative readmission reduction, and hospitals below the line did achieve 20% relative readmission reduction.

Table 1

Median Changes in Risk-Adjusted 30-Day Readmission Rates Between 2009 and 2012 per Baseline Quartile of 30-Day Risk-Adjusted Readmission Rate*

Quartile	Readmission Rate in 2009, %	Median Relative Change in Readmission Rate, 2009–2012, % (Interquartile Range)
1	17.18–19.32	−0.9 (−3.1 to 4.6)
2	19.33–19.91	−4.9 (−7.4 to 0.5)
3	19.92–20.66	−7.0 (−10.4 to −2.6)
4	20.67–23.11	−8.7 (−12.9 to −5)

*$P = .003$

Table 2

Site-Level Characteristics by Quartiles of Percent Change in 30-Day Risk-Adjusted Readmission Rates, 2009–2012

Variable	Overall (N = 70)	Best Quartile (n = 17)*	Quartile 2 (n = 18)*	Quartile 3 (n = 18)*	Worst Quartile (n = 17)*	*P* Value
Mean age, median (quartiles), y	80.0 (78.2–81.7)	80.7 (78.2–81.7)	80.7 (78.2–82.2)	79.9 (78.2–80.8)	79.4 (78.7–81.3)	.81
Female, median (quartiles), %	53.6 (50.2–57.8)	56.3 (51.2–59.2)	52.6 (49.6–57.4)	52.7 (47.1–55.9)	54.3 (51.4–58.2)	.36
Race other than white, median (quartiles), %	14.6 (6.5–31.3)	15.4 (5.1–30.3)	18.0 (10.8–35.7)	10.7 (4.2–30.2)	12.2 (7.3–39.2)	.65
Insurance, median (quartiles), %						
Medicare	83.1 (43.3–97.2)	77.8 (39.3–91.5)	83.9(53.0–96.7)	93.2 (50.9–98.0)	67.9 (38.3–97.2)	.44
Medicaid	3.0 (0.3–8.3)	5.3 (1.5–7.7)	3.2 (0.4–14.8)	1.1 (0.0–6.7)	3.1 (0.4–8.1)	.54
Other	13.0 (1.8–36.5)	11.11 (4.5–36.5)	13.0 (1.9–27.5)	5.3 (1.1–35.6)	21.1 (2.2–38.7)	.63
Medical history, median (quartiles), %						
Atrial fibrillation	40.0 (32.6–44.9)	40.0 (34.0–42.9)	34.9 (32.0–46.7)	39.4 (32.0–45.7)	42.0 (32.6–44.9)	.98
COPD	29.2 (24.1–34.2)	29.2 (25.0–33.2)	30.6 (23.3–33.8)	29.2 (24.6–34.2)	28.4 (24.8–36.3)	.99
Cerebrovascular accident/TIA	16.8 (13.3–19.6)	16.8 (13.7–20.2)	16.1 (13.0–19.1)	16.4 (12.3–19.3)	17.6 (16.4–20.5)	.57
Dialysis	2.7 (1.6–4.0)	3.1 (2.4–3.9)	2.1 (1.2–4.0)	2.7 (1.6–3.9)	2.6 (1.8–4.2)	.78
Renal insufficiency	19.5 (11.6–26.9)	23.1 (13.2–33.9)	22.7 (16.1–27.6)	11.8 (9.6–23.6)	16.1 (11.6–22.2)	.05
History of ischemia†	58.8 (50.9–63.5)	58.9 (50.2–62.5)	58.3 (50.6–62.4)	57.3 (48.3–66.6)	60.4 (55.0–63.9)	.69
Smoking	10.1 (5.5–12.8)	10.1 (5.2–13.5)	10.5 (7.0–12.5)	11.3 (6.2–13.8)	9.5 (5.4–10.6)	.67
Vital signs						
Mean systolic blood pressure, median (quartiles), mm Hg	141.6 (137.9–146.0)	145.0 (138.9–147.3)	141.6 (137.2–146.2)	140.3 (138.3–144.4)	141.1 (139.2–144.5)	.70
Admission laboratory test results						
Mean creatinine, median (quartiles), mg/dL	1.6 (1.5–1.7)	1.6 (1.5–1.8)	1.7 (1.6–1.8)	1.6 (1.4–1.7)	1.6 (1.6–1.6)	.40
Mean BUN, median (quartiles), mg/dL	29.7 (28.7–31.6)	30.9 (29.8–32.6)	29.5 (29.1–32.6)	29.1 (27.6–30.7)	29.2 (28.1–30.3)	.09
Mean BNP, median (quartiles), mg/dL	1216.6 (1017.1–1573.4)	1129.2 (955.3–1465.0)	1222.8 (1126.9–1550.6)	1124.3 (895.4–1890.7)	1286.0 (1116.0–1826.8)	.29
Discharge laboratory test results						
Mean creatinine, median (quartiles), mg/dL	1.7 (1.5–1.8)	1.6 (1.5–1.8)	1.7 (1.7–1.9)	1.6 (1.3–1.7)	1.6 (1.5–1.7)	.10
Weight change, mean, kg	2.5 (1.6–2.9)	2.4 (1.2–2.7)	2.4 (2.0–2.9)	2.6 (1.6–3.0)	2.4 (1.0–2.7)	.96
Hospital characteristics						

Variable	Overall (N = 70)	Best Quartile (n = 17)*	Quartile 2 (n = 18)*	Quartile 3 (n = 18)*	Worst Quartile (n = 17)*	*P* Value
Heart failure disease management referrals, %	5.4 (0.0–16.0)	12.4 (1.3–37.5)	5.9 (0.73–13.0)	0.0 (0.0–12.6)	5.4 (0.5–16.0)	.10
Discharge instructions (%)	95.8 (90.5–98.1)	95.9 (90.2–98.2)	96.0 (90.5–99.0)	96.8 (92.6–98.2)	94.4 (90.5–97.4)	.85
β-Blocker for LVSD, %	97.6 (95.0–99.0)	97.8 (96.0–99.0)	97.0 (95.4–98.7)	97.7 (93.3–100.0)	97.6 (96.6–98.6)	.97
ACE inhibitor/ARB for LVSD (%)	96.2 (92.5–98.9)	97.3 (93.8–100.0)	96.7 (90.0–100.0)	96.0 (93.3–98.9)	94.4 (91.9–97.3)	.32
Length of stay, median (quartiles), d	4.0 (4.0–5.0)	4.0 (4.0–4.0)	4.0 (4.0–5.0)	4.0 (3.0–4.0)	4.0 (4.0–5.0)	.33
Teaching hospital, %	67.1	58.8	55.6	72.2	82.4	.31
Rural setting, %	4.3	5.9	0	11.1	0	.51
Cardiac intensive care unit, %	74.6	68.8	70.6	78.6	81.3	.85
Cardiac catheterization lab, %	88.9	81.3	88.2	92.9	93.8	.76
Number of beds, median (quartiles)	370.0 (217.0–555.0)	328.0 (194.0–428.0)	339.5 (222.0–601.0)	324.5 (175.0–575.0)	465.0 (372.0–531.0)	.34
Annual discharges, median (quartiles)						
Medicare	6534 (4534–9341)	6534 (3280–8296)	6061 (4556–10,661)	5211 (3328–9378)	8490 (6131–10,555)	.22
Medicaid	2715 (1281–4837)	2209 (1027–4837)	2678 (1366–5191)	2408 (1311–4747)	4364 (2367–5262)	.44
US geographic region, %‡						.81
West	18.6	17.7	22.2	16.7	17.7	
South	32.9	29.4	44.4	38.9	17.7	
Midwest	21.4	17.7	16.7	16.7	35.3	
Northeast	27.1	35.3	16.7	27.8	29.4	
Cardiologists per 100,000	5.7 (4.8–7.7)	7.2 (5.0–7.9)	5.3 (4.4–6.1)	6.2 (5.1–8.1)	5.6 (4.8–6.8)	.43
Prescription drug effectiveness, %						
Post–MI β-blocker prescription filled						
1 to 6 months	84.0 (80.6–88.4)	84.9 (82.4–88.8)	84.4 (82.1–88.8)	83.9 (79.8–86.2)	82.9 (78.6–88.8)	.85
7 to 12 months	79.2 (73.3–82.6)	79.3 (76.5–81.5)	79.4 (75.3–82.1)	80.8 (75.5–84.3)	74.2 (72.3–81.8)	.42
ACE inhibitor/ARB prescription filled§	74.3 (72.6–76.4)	74.8 (72.7–76.4)	74.1(72.2–76.7)	74.1 (72.6–76.5)	74.5 (71.8–76.3)	.97

Abbreviations: ACE, angiotensin-converting-enzyme; ARB, angiotensin II receptor blocker; COPD, chronic obstructive pulmonary disease; BNP, B-type natriuretic peptide; BUN, blood urea nitrogen; LVSD, left ventricular systolic dysfunction; MI, myocardial infarction; TIA, transient ischemic attack.

*History of ischemia includes coronary artery disease, prior myocardial infarction, or prior revascularization (ie, percutaneous coronary intervention or coronary artery bypass graft surgery).

†Best quartile, −21.0% to −8.8% (n = 17); quartile 2, −8.7% to −5.8% (n = 18); quartile 3, −5.5% to −0.9% (n = 18); worst quartile, 0.2% to 15.5% (n = 17).

[‡]US geographic regions include the following states, with weights shown in parentheses: Northeast (19) includes Connecticut (3), Massachusetts (3), New Jersey (2), New York (5), and Pennsylvania (6). Midwest (15) includes Illinois (1), Indiana (2), Kansas (2), Michigan (1), Missouri (3), Ohio (4), South Dakota (1), and Wisconsin (1). South (23) includes Alabama (2), Florida (4), Georgia (1), Kentucky (1), Louisiana (2), Mississippi (1), North Carolina (1), Oklahoma (1), South Carolina (2), Tennessee (3), Texas (3), Virginia (2). West (13) includes Alaska (1), California (3), Colorado (3), Hawaii (1), Idaho (1), New Mexico (1), Nevada (1), and Washington (2).

[§]For patients with diabetes mellitus only.

Table 3

Association of Site-Level Factors and Relative Percent Change in 30-Day Risk-Adjusted Readmission Rates Between 2009 and 2012

Site Factor	Estimate (95% CI), %	*P* Value
Percent of patients referred to a heart failure disease management program	−0.09 (−0.18 to −0.01)	.03
Percent ACE inhibitor/ARB for patients with LVSD	−0.27 (−0.63 to 0.09)	.14
Teaching site	3.54 (0.03 to 7.05)	.05

†Variables listed were chosen based on forward selection to be included in multivariable linear regression model. Each site's relative risk-adjusted 30-day readmission rate was used as the dependent variable in the model.